# Code Questions and Answers

**John Wiles**

Sponsored by the Photovoltaic Systems Assistance Center, Sandia National Laboratories

Understanding the *National Electrical Code* is not a simple task. If you are ever uncertain about what the code means, you should be safe and find out through one of the many resources available to you. As the *Code Corner* columnist for *Home Power* and through my work with Sandia National Laboratories, I receive many questions on code-related topics. I'm always happy to answer your questions. On a regular basis, I plan to share some of those questions and their answers in this column. Here are some recent questions I've received.

## Are "Double-Taps" a Code Violation?

**Q** Is it a code violation to make "double-taps" (more than one wire) on circuit breakers or panel lugs in any application, but specifically in residential applications? If it is a violation, where is it located in the *NEC*?

I have purchased a house, and the electrical inspector stated that there could be no double-taps. I have been a construction electrician for 40-plus years and have made numerous double-taps when needed. Perhaps I have been wrong in doing so. My criteria in doing so were:

- Each wire size had to be correct for the breaker rating.
- The breaker had to have a termination that would handle more than one wire and not just be under the head of a screw.

There is a section in the code just for downsized wiretap rules. How are they to be accomplished if there are to be no double-taps?

In checking out Cutler-Hammer's Web site, they list the BR breaker that can only have one wire and the CH breaker that can have two wires. If both breaker terminations are setscrew types and have adequate room, why can't both breakers be rated for two wires? It seems to me the only concern is for a tight connection so that no heat is generated. Maybe I am wrong, so I would appreciate your input.

**A** *Double-tapping or double-lugging is a very common code violation, mainly because many people do not read all the markings and instructions that come on or with the product. Inspectors red-flag double-tapped or double-lugged connections nearly every day.*

*Section 110.3(B) requires that all equipment be installed and used in the same manner in which it was listed and tested, following all instructions that accompany or are available for the product. Section 110.14(A) requires that terminals suitable for more than one conductor be so identified.*

*While you list good practices, these rules are not sufficient to ensure a long-lasting termination. A terminal listed for #14 to #2/0 (AWG) conductors has room for about ten or more #14 conductors. However, tests at UL and practical experiences throughout the country indicate that the terminal may not remain tight when more than one conductor of any size is used, unless that terminal is specifically tested and listed for use with more than one conductor. That information is found marked on the product (molded into or printed on circuit breakers), on the disconnect labels, in the instruction manuals for load centers, in the catalogs for some of the products, and on the cut sheets for other products.*

*A number of splicing devices are available that can connect two or more wires together. They include twist-on wire connectors, split bolts, insulated splicing blocks, bus bars, and others. All are available in any electrical supply house. These devices allow many conductors to be connected to a single breaker legally and in a code-compliant manner.*

*Physical space is not the criteria. Each conductor must stay connected through rigorous thermal cycling and mechanical pull tests. I have not seen the breakers that you mention, but I suspect that they have a square plate under the setscrew or some other clamping device that clamps both conductors equally to the breaker. The smaller Square D QO breakers have a similar feature.*

*For PV systems, which will be generating electricity for the next 50-plus years, the goal is that all connections meet code and do not come loose for those 50-plus years. Following the guidance and instructions supplied by the manufacturer and the code is the best way to ensure a safe and long-lasting connection.*

## Why Did I Fail My Inspection?

**Q** I recently installed a grid-tied 4,950-watt PV system. I failed the inspection allegedly because I ran the wires in the wall using a 1/2-inch EMT conduit. I read in your magazine that such type of conduit not only is allowed, but requested by the 2005 *National Electrical Code (NEC).* The inspector claims that it is not allowed by the 1999 *NEC* and that's the code New York State still uses. That was why he failed the installation and said that I must rerun the wire on the roof (rather than the attic and wall) in a PVC conduit. It seems to me he is really shooting from the hip. Can you help? Do you have any suggestions?

**A** *The 2005* NEC*, in Section 690.31(E), requires the use of a metallic raceway when PV source and output conductors are run inside a building prior to reaching the main PV disconnect. The code does not require that this routing be used since it is also possible to run the conductors in* *conduit down the outside of the building to the readily accessible disconnect required by 690.14.*

*Editions of the* NEC *prior to the 2005* NEC *did not have this provision for the use of metallic raceways inside the building, and all installations were required to keep the PV circuits outside the building until reaching the readily accessible disconnect described in 690.14. Section 690.14 was specifically written into the code by the NFPA in the 2002* NEC *because this language was not in previous editions of the code, which referred the installer back to Article 230. Essentially, until the 2005* NEC*, the DC PV circuits from the array had to be handled in a manner similar to AC service entrance circuits.*

*Various states adopt the* NEC *as the local state law when they get around to it. Some states adopt it automatically on January 1st of the year the new edition is issued. Others are way behind, like California, which just started using the 2002* NEC*. Others are even further behind, such as New York.*

*The inspector is fully justified in using the code that is legally required in his jurisdiction. However, as the authority having jurisdiction (AHJ), he may apply whatever rules and requirements he feels are proper. Be friendly, it can go a long way toward establishing a positive relationship with your local inspector.*

## Inverters in Parallel

**Q** My question is about paralleling the outputs of two inverters (Fronius IG 4.0 KW) into one for a grid-tied application. Must I always use a dedicated subpanel for paralleling inverters together? I would rather not because of cost and space constraints, and because I will be using a fused AC disconnect to meet our utility's requirements and *NEC* requirements for overcurrent protection between the inverter output circuit and the grid. I would prefer to use a Burndy terminal adapter/connector (see photo) to combine the two inverter outputs together. I could be wrong, but I believe the code describes the use of certain connectors, such as twist-on wire connectors, which can be used for combining inverters.

**A** *The* National Electrical Code *does not allow the outputs of two or more inverters to be directly paralleled. Section 690.64(B)(1) requires that the output of each utility-interactive inverter be connected to a dedicated circuit breaker or fusible disconnect. The "dedicated" nature of this circuit and connection is to ensure that nothing else is connected to the output of the utility-interactive inverter, including loads and other inverters. The use of a dedicated circuit allows each inverter to be turned off independently for servicing, and prevents the possibility of anything being connected directly to the inverter output that might, under unusual circumstances, cause it to continue running after it was disconnected from the grid.*

*After connecting the two inverters through the two dedicated overcurrent or disconnect devices, you may parallel the circuits in several ways using listed components for the task, such as the splicing connectors that you have indicated. However, you must apply the requirements of 690.64(B)(2) to all of the conductors involved in the splice. These requirements involve the rating of each of the dedicated overcurrent devices, the overcurrent device that feeds the combined output to the grid, and the size of each of the conductors.*

*It is usually simpler to just backfeed a couple of circuit breakers in a standard load center than to go through all of the above exercise. A properly selected load center will meet both 690.64(B)(1) and 690.64(B)(2) requirements in a single device that may be smaller than the two separate overcurrent devices (in their enclosures) and a splicing device in its enclosure. Once the requirements for separate disconnects for each inverter are met, the utility should allow combining the two sources into one utility disconnect.*

## Integrated Overcurrent Devices

**Q** I have a question about paralleling inverters: It makes sense from a servicing perspective to have a dedicated overcurrent device for each inverter. However, many inverters nowadays come with these devices integrated into the inverter case (Fronius and Xantrex GT 3.0, for example). An overcurrent from the grid, backfeeding to the inverters, would be covered by the fused AC disconnect or breaker between the grid and the inverter, but a failure in one of the inverters could damage the other inverter (if they were parallel spliced—for lack of a better term—together). But with integrated overcurrent and disconnecting devices inside the inverters, it seems they should be self-protected…

I'm sure that I am missing something. And this probably gets into certification and testing agencies listing the internal devices and the equipment, and then this finding its way into the *NEC*, which I'm sure takes decades.

One more question—is it possible to use a terminal adapter (previously mentioned) to combine two combiner boxes and PV output circuits prior to landing them in an inverter DC disconnect?

**A** *An additional consideration is the requirement that the AC and DC disconnects for the inverter be available to service the inverters. Many inspectors will not accept the internal disconnects as meeting these disconnect requirements, since they may expose the unqualified person pulling the inverter for service to dangerous voltages. I am neutral on this subject, but many inspectors are not. Usually these disconnects must be in sight of the product being serviced. Also some inverters that do not have internal AC breakers, such as the Sunny Boy SB2500,*

**The output of two inverters could be combined by using a splicing device such as this Burndy insulated power block—but only if you connect the inverter outputs to dedicated overcurrent devices or disconnects first.**

*require an external, dedicated overcurrent device to protect internal circuitry. If UL looked into this, many more inverters would probably require this external overcurrent device as part of the listing.*

*Yes, you can always parallel circuits, if each set of conductors is protected from faults from all sources or has ampacity greater than any possible fault currents. In the case of the outputs of two DC PV combiners, the cables should all be rated at 1.56 times the sum of the two short-circuit currents being fed to the inverter. This would be no different than the bus bar ratings in the output of a single, fused combiner, and some combiners are designed to facilitate such paralleling.*

## Questions or Comments?

If you have questions about the *NEC* or the implementation of PV systems that follow the requirements of the *NEC*, feel free to call, fax, e-mail, or write me. Sandia National Laboratories sponsors my activities in this area as a support function to the PV industry. This work was supported by the United States Department of Energy under Contract DE-FC04-00AL66794. Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy.

## Access

John C. Wiles, Southwest Technology Development Institute, New Mexico State University, Box 30,001/ MSC 3 SOLAR, Las Cruces, NM 88003 • 505-646-6105 • Fax: 505-646-3841 • jwiles@nmsu.edu • www.nmsu.edu/~tdi

*2005 PV Power Systems and the NEC: Suggested Practices*, a 143-page manual, can be downloaded from the SWTDI Web site • www.nmsu.edu/~tdi

2008 *NEC* Proposals PDF • www.nmsu.edu/~tdi/pdf-resources/2008NECproposals2.pdf

Sponsor: Sandia National Laboratories, Ward Bower, Dept. 6218, MS 0753, Albuquerque, NM 87185 • 505-844-5206 • Fax: 505-844-6541 • wibower@sandia.gov • www.sandia.gov/pv

The 2005 *NEC* & the *NEC Handbook* are available from the NFPA, 11 Tracy Dr., Avon, MA 02322 • 800-344-3555 or 508-895-8300 • Fax: 800-593-6372 or 508-895-8301 • custserv@nfpa.org • www.nfpa.org